Regional Transit Long-Range Plan Update

Issue Paper on Innovation Fund

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Contents

Tables

Acronyms and Abbreviations

BART	Bay Area Rapid Transit
CTR	commute trip reduction
CV	connected vehicles
HCT	high-capacity transit
Metro	Los Angeles County Metropolitan Transportation Authority
MTS	San Diego Metropolitan Transit System
ORCA	One Regional Card for All
SEIS	supplemental environmental impact statement
SOV	single-occupant vehicle
ST2	Sound Transit 2
TDM	transportation demand management
TfL	Transport for London
TNC	transportation network companies

Executive Summary

The voter-approved 1996 *Sound Move* plan included an "Innovation Fund," described as a program to "evaluate and fund innovative ways to provide transit service, reduce dependency on single-occupancy vehicles, improve public transportation's cost effectiveness, and better respond to customer needs" (Sound Transit 1996). In 2007, Sound Transit adopted Sound Transit 2 (ST2), which included provisions for a Technology Fund. Through this funding, Sound Transit has implemented research and technology programs that have delivered systems such as electronic fare collections, traffic-signal priority, and advanced security monitoring. The research and technology program continues to fund developments in transit data collection and dissemination, variable messaging signs, and real-time passenger information.

This issue paper identifies a variety of ways in which Sound Transit could consider improving its Innovation Fund to better meet the needs of its riders, while also using its resources most efficiently. This paper also provides guidance on potential areas of transit research and innovation based on best practices from peer transit agencies as well as initiatives by other public agencies and businesses.

A review of major areas involving a variety of innovation-related topics provided key direction for this issue paper. Major topics addressed in the case studies include the following:

- Big data, particularly information from smartcards
- Transportation demand management (TDM)
- Parking management
- Access to high-capacity transit service—first mile/last mile
- Customer experience with the high-capacity transit (HCT) system

For each of these major topics, this issue paper presents information from case studies that involve transit-related approaches to innovation. Both benefits and challenges are described. Several innovation-related areas could provide substantial promise in helping Sound Transit assess future direction relating to HCT operations and planning while also benefitting the agency's customers.

Additionally, this paper presents potential strategies for pursuing innovation-related opportunities. The final section includes draft language that could be considered in the Long-Range Plan Update that addresses continued research and investment in the areas of innovation and technology. Table 1 provides an overview of key findings relating to potential innovation-related approaches.

Table 1. Summary of innovation-related findings

Innovation topic	Potential approaches	Key benefits				Addressing potential challenges
		Ridership growth	Expanded application	Customer satisfaction	Cost savings	
Using big data—smartcard and open data	Expand use of anonymized ORCA data	Data to target new markets and increase ridership	Analyze anonymous ORCA data to reveal ridership patterns		Reduced costs for surveys and modeling for travel forecasts	Data security and access issues have been surmounted by other transit agencies. Additionally, state laws impose privacy restrictions on personally identifying information.
	Open anonymous ORCA data for analysis			Customer-based apps developed by third parties	Research partnerships and crowdsourcing to minimize agency costs	Privacy concerns could be addressed by anonymizing and aggregating research data.
	Incorporate outside sources (e.g. CTR, Census data, etc.)	Ridership pattern info to identify and target markets	Multiple sources of data for operations analysis			Collaborations with organizations outside Sound Transit could minimize costs.
Transportation demand management	Support existing TDM programs — employers	Ridership gains without major operating and capital costs increases				Coordination of transit agencies, cities, employers, etc. requires explicit stakeholder involvement.
	Expand existing TDM programs—residential areas	Home-end TDM near HCT stations could increase ridership				Stakeholder coordination needed to reduce barriers to joining home-end TDM programs.
Parking management	Expand existing pilot program	Increased carpool to P&Rs, and decreased non-transit use at P&Rs free capacity		Improved parking access for transit riders		Coordination would be required regarding access planning and design for HCT extensions.
	Shared parking with nearby attractors				Reduced capital and operating costs for increased capacity	Potential issues can be identified on a station-specific basis .
First and last mile	Coordinate with other alternative transportation providers	Higher ridership could by accommodating new forms of rider drop-offs	Possible consolidation of payments for all modes	Ease of payments by transit customers	Higher ridership could be achieved without a major increase in capital costs	Design facilities for collocated services (carshare, etc.) and expanded passenger drop-off from private rideshare services.
Customer experience	Provide mobile ticketing opportunities	Fare purchase by mobile devices to expand casual and event ridership			Reduces cash fare processing costs and appeals to more riders	Perception that smartphone users are affluent is contradicted by current market data.
Smart and Connected vehicles	Monitor advances in vehicle tech for transit application	More efficient operation could increase productivity	Efficiency and safety improvements	Improved ride quality and reliability	Improved efficiency, productivity and safety	Research and monitoring of industry, federal direction needed for costly future investments.

1 Introduction

Sound Transit is updating its Regional Transit Long-Range Plan. As part of the update, a variety of potential areas of transit research, innovation, and industry best practices are being considered that could provide direction for the Long-Range Plan Update as well as for Sound Transit's next phase of system planning.

1.1 Purpose of this issue paper

The Innovation Fund Issue Paper addresses the following topics:

- Guidance on potential areas of transit innovation based on a review of innovation-related case studies
- Findings for how Sound Transit could more efficiently assess and implement new business practices associated with innovative approaches and any related technologies to better meet transit riders' needs
- Possible revisions to the current Long-Range Plan based on industry best practices and emerging trends as well as innovations that could be considered for Sound Transit's next system plan
- Findings regarding innovative ways to provide transit service, reduce dependency on single-occupancy vehicles, improve public transportation's cost effectiveness, and better respond to customer needs

This paper will provide Sound Transit with possibilities for incorporating forward-thinking approaches to the design and delivery of services that will best position the agency to take advantage of industry best practices investigated in this paper.

2 History of the Sound Transit Innovation Fund

The voter-approved 1996 *Sound Move* plan included an "Innovation Fund," described as a program to "evaluate and fund innovative ways to provide transit service, reduce dependency on single-occupancy vehicles, improve public transportation's cost effectiveness, and better respond to customer needs" (Sound Transit 1996). This concept included technological innovations, ways to reduce environmental impacts, and incentives and programs to encourage more people to use regional transit (transportation demand management).

In 2007, Sound Transit adopted Sound Transit 2 (ST2), which included provisions for a Technology Fund. Through this funding, Sound Transit has implemented research and technology programs that have delivered systems such as electronic fare collections, traffic-signal priority, and advanced security monitoring. The research and technology program continues to fund developments in transit data collection and dissemination, variable messaging signs, real-time passenger information, parking monitoring, fare collections and E-commerce solutions, and on-board technology such as elements of smart bus and passenger wireless internet.

The potential expansion of HCT and facility enhancements in the central Puget Sound region can be complemented by efforts to implement additional innovative programs. While potential expansion of HCT services could require a major commitment of public resources, innovative approaches could yield substantial benefits to Sound Transit's customers and increase capacity and efficiency to serve more riders without necessarily incurring the kinds of major costs that new large capital investments require. Facilities and service already developed under *Sound Move* and ST2 could be made more productive from potential innovative strategies. The findings identified in this issue paper include relatively low-cost approaches that could generate major benefits to Sound Transit as well as current and future customers.

3 Areas of Innovation

This section provides an overview of promising innovations, industry best practices, and emerging trends for public transportation innovations and business practices. A substantial number of innovation-related topics could be explored by this issue paper. The selected topics have one or more of the following benefits in terms of value for future HCT development in the central Puget Sound region, as well as for existing facilities and those in design and construction:

- Increased ridership
- Improved customer satisfaction
- Cost savings

Key innovation-related topics identified by Sound Transit are summarized in Table 2 and include the following:

- Big data
- Transportation demand management
- Parking management
- First mile/last mile access
- Customer experience

For each innovation area, Table 2 identifies various innovations that were explored; for example, big data subjects include smartcard, open data, and local jurisdiction/cell phone/crowd-sourced data. The table also identifies case studies relating to elements of major topics as well as potential benefits and challenges. The following sections further describe research results for major innovation-related topics.

3.1 Big data

Big data is a relatively new term used to describe the availability and use of large amounts of information that can be collected from a number of sources, including cell phones and transit-fare payment methods such as smartcards. Smartcards have been introduced by many transit systems throughout the United States and internationally. While their initial purpose was to facilitate revenue collection, smartcards also produce large quantities of transaction data that can be useful to planners, operations analysts, and ultimately transit riders. This topic explores some of the opportunities and best practices associated with the use of smartcard data as well as benefits and potential challenges.

Table 2. Innovation-related topics

Innovation topics	Example case study	Benefits
Big data		
Smartcard data	Transport for London uses smartcard data in a variety of ways, including developing origin-destination matrices that can inform systemwide planning.	• Gain efficiency—Identify service gaps and repetition, track performance measures, validate runtime estimations • Increase revenue—Better fare policy, potential for public–private partnerships in expanded use of smartcard • Improve customer satisfaction—Riders can use one card for multiple purposes, contact/alert users through mailing lists regarding service improvements or problems
	San Diego is mapping smartcard data to better understand transfer points and existing service delivery.	
	Many reports have highlighted the diverse benefits of using smartcard data and the potential to generate revenue through partnerships with private companies.	
Transit open data	A number of transit agencies (including London, Chicago, San Francisco, and Boston) have made all of their service data available for public use. This has resulted in the creation of a variety of mobility apps and data visualizations.	• Improve customer satisfaction—Improved transparency, reliability, and dependability • Reduce costs—Remove need to provide official apps by crowdsourcing innovation
City, cellphone, and crowd-sourced data	A number of private companies offer anonymous cell-phone location data. Some transit agencies have begun using this data to gain an understanding of the transportation use patterns in an area.	• Gain efficiency—Identify service gaps and repetition • Grow ridership—target new markets
	A variety of new smartphone apps, including Tiramisu in New York, allow transit riders to share/report transit information. The aggregation of data makes it possible for everyone to be better informed about happenings in the transit network.	• Reduce costs—Remove need to provide official apps by crowdsourcing innovation • Improve customer satisfaction—Improve transparency
Maintenance Data	There is an opportunity to track maintenance data to develop maintenance strategies, inform state of good repair decisions, and determine provisions for capital replacement.	• Gain efficiency—Proactively consider state of good repair • Reduce costs—preventative maintenance can be more cost effective than fleet and infrastructure replacement
Transportation demand management		
Private/public transportation agreements	San Francisco is currently running a pilot program that requires private shuttle operators to obtain permits for using city bus stops.	• Improve overall mobility—Minimize service repetition with private sector as private transport services supplement public services, especially in suburban areas • Increase revenue—Earn revenue from private use of public infrastructure
Expanded demand management programs	King County's In Motion program works with community groups to develop context-specific TDM programs and work to expand demand management programs into multi-family developments	• Improve customer satisfaction—Design specialized programs for community needs • Reduce SOV travel/improve transit mode split
	Downtown on the Go, a transportation advocacy group in Tacoma, has partnered with private and public stakeholders to further the reach of the Washington State CTR program and spread awareness regarding transit/non-motorized opportunities in Tacoma. Private shuttle services, such as those provided by Seattle Children's Hospital and Microsoft, provide alternative transportation choices to the SOVs.	• Improve customer satisfaction—Improved transparency • Reduce SOV travel/improve transit mode split

Table 2. Innovation-related (continued)

Innovation topics	Example case study	Benefits
Parking management		
Parking reservations	Bay Area Rapid Transit offers a variety of permit options (including monthly and single day) that can be bought online and ahead of time.	• Improve customer satisfaction—Improved transparency, reliability, and dependability • Increase revenue—Pass on cost of parking to riders
	Parking applications being utilized in U.S. cities (e.g., Washington D.C., San Francisco, and San Diego) allow riders to see available parking spaces and make reservations ahead of time.	• Improve customer satisfaction—Improved transparency, reliability, and dependability
	The Los Angeles County Metropolitan Transportation Authority identified a number of strategies for mitigating growing parking demand, including wayfinding, signage, shared parking, fees, and land use reform.	• Reduce costs—Minimize need to build new parking facilities • Improve customer satisfaction—Improved transparency and safety
Shared parking agreements	Tri-Met Park & Ride in Portland encourages shared parking near transit stations. Metro—Portland developed handbook to support shared parking.	• Reduce costs—Minimize need to build new parking facilities • Improve efficiency—Existing infrastructure is better utilized
	King County Metro developed Right Size Parking, an initiative to better utilize existing parking and mitigate the need to build new parking infrastructure.	• Reduce costs—Minimize need to build new parking facilities • Improve efficiency—Existing infrastructure is better utilized
Priced parking	SFpark, a pilot program in San Francisco, dynamically priced parking in many neighborhoods to manage demand.	• Improve customer satisfaction—Improved transparency and dependability • Increase revenue—Potential to earn higher revenue from public use of city parking
First mile/last mile access		
Improved access to alternative modes	Two pilot programs in Pasadena, California subsidized the cost of purchasing electric/folding bikes. Participants were financially incentivized to use bikes instead of their cars when travelling a short distance to a transit station.	• Reduce costs—Minimize need to build new parking facilities • Ridership growth—Target new markets with improved safety and non-motorized access • Reduce SOV travel/improve transit mode split
	Los Angeles has developed a strategic plan that includes goals and polices for supporting last mile solutions.	• Reduce SOV travel/improve transit mode split • Improve overall mobility
Shared modes of transportation	Zipcar collaborated with the local transit agency in Cincinnati to bring carsharing to transit hubs.	• Reduce SOV travel/improve transit mode split • Improve overall mobility • Reduce costs—savings—Reduced need for agencies to provide transit service in the last mile
	A pilot program began in San Francisco in summer 2014 that offers 900 parking spaces exclusively to car-sharing companies.	• Reduce SOV travel/improve transit mode split • Improve overall mobility
	Zimride is a private company with a culture and business model around carpooling.	• Reduce SOV travel/improve transit mode split
	Car2go in Seattle gives residents access to driving without having to own their vehicle.	• Reduce SOV travel/improve transit mode split • Improve overall mobility
	Bikesharing systems, such as Citi Bike in New York City, provide riders with a driving alternative	• Reduce SOV travel/improve transit mode split • Improve overall mobility

Table 2. Innovation-related (continued)

Innovation topics	Example case study	Benefits
Customer experience		
Branding and wayfinding	By focusing on branding and wayfinding, transit agencies can change the public's perception of transit, target new rider groups and make transit more appealing.	• Improve customer satisfaction • Grow ridership—target new markets
Mobile payments	Tri-Met in the Portland region offers its riders the ability to purchase transit tickets through a phone app.	• Improve customer satisfaction—Riders buy tickets conveniently • Reduce agency costs—Minimize need for cash processing and point-of-sales infrastructure • Reduce customer costs—No need for $5.00 purchase of pass
On-time performance	New tools allow transit systems to run more efficiently by using GPS data to manage network-wide bus spacing and minimize bus bunching.	• Efficiency gains—Ability to optimize transit runs • Improve customer satisfaction—Improved reliability, increased dependability and decreased over-crowding

3.1.1 Big data best practice: Using smartcard data

The introduction of an integrated regional fare system in the last 10 years allowed Sound Transit, in partnership with other transit agencies, to streamline the fare collection process. This fare system has transitioned into the One Regional Card for All (ORCA) that also has the capability to collect anonymous data on ridership patterns of transit users.

For Sound Transit and its transit partners, data from ORCA card transactions has been limited to fare-related information. However, smartcard data could be used to help assess and improve transit services and to support facility planning—both short- and long-term. One potential example is transfer data that could support analysis by Sound Transit and its transit partners on bus/rail integration.

Additional ways smartcard data have been used by other transit systems include runtime estimations, contact lists for service alerts, complex fare-structure analysis, preventative fleet maintenance assessments, and implementation of loyalty programs. The use of smartcard data can be cost effective since agencies can utilize a rich dataset that is already funded and built.

Case study: Origin-destination networks, Transport for London—London, UK (Transport for London 2014)

Transport for London (TfL) uses its extensive smart card database to build origin-destination matrices and demand models to better understand its riders' travel behavior. To check the validity of their models, TfL cross-references its assumptions with survey data.

While TfL's in-house group processes its smartcard data, it also partners with universities to conduct research regarding travel behavior and trends. At the Massachusetts Institute of Technology (MIT), many projects were later used to inform system-wide planning by TfL (Sanchez-Martinez 2014). Partnering with universities provides an opportunity for a transit operator to analyze large quantities of data with a reduced need for additional agency staff and associated costs.

Case study: Transfer analysis, San Diego Metropolitan Transit System—San Diego, CA (Henschen 2014)

The San Diego Metropolitan Transit System (MTS) recently began processing its large repository of transit data. MTS has begun using *Urban Insights*. *Urban Insights* is big-data service provided by MTS's supplier of smart-card and revenue management software to analyze its smartcard data. MTS is currently using its data to assess system transfers and level of service at transit stations. MTS also hopes to expand the scope of its analysis to include topics such as fare evasion. MTS reportedly uses additional data sources, such as automatic passenger counters, to verify its model assumptions.

Case study: "Smart Card Data in Public Transit Planning: A Review"—academic paper, University of Montréal and University of Quebec (Morency 2009)

In the academic paper, *Smart Card Data in Public Transit Planning: A Review,* authors identify a number of opportunities associated with using smartcards. One opportunity is the ability to use smartcards as a means of revenue generation through public–private partnerships. Transit agencies can leverage private interest in having access to large volumes of transit data. Transit data could also be useful to the private sector as a way to identify new customers. A few ways in which cities have partnered with private companies in mutually beneficial agreements include the development of a transit loyalty program in drugstores in the United Kingdom, and enabling smartcards to interact with vending machines in Hong Kong.

3.1.2 Big data best practice: Make transit data open and easily accessible to the public

As noted in the previous section, big data can provide a substantial information resource for transit systems. While this data has traditionally been used for internal processes only, some agencies have publicly released transaction data to the public and thus empowered innovation in delivering transit information to riders through a variety of platforms, including mobile applications.

Case study: Public data sharing, Transport for London—London, UK (Transport for London 2014)

TfL offers free access to a variety of the data it collects. Additionally, TfL permits commercial use of its data and only has minor limitations regarding requirements and exemptions. TfL's data portal clearly identifies the types of data that exist, format of the data sets, goals of TfL's data sharing program, and rules and expectations regarding design standards. TfL's open data has led to a number of rider tools, including arrival-prediction apps and route planning.

A number of U.S. transit providers have also set up transit data portals, including Bay Area Rapid Transit (San Francisco Bay Area Rapid Transit "For Developers"), Chicago Transit Authority (Chicago Transit Authority "Open Data from CTA"), and the Massachusetts Bay Transportation Authority (Massachusetts Bay Transportation Authority "Rider Tools"). Some ways open data have been used include visualizing level of service in San Francisco (Frustration Index), tracking mobility patterns across cities (Human Data), and linking transit data with other datasets (*The New Yorker* 2013).

3.1.3 Big data best practice: Using local agency, cellphone, and crowd-sourced datasets

While transit agencies collect a large amount of data that can be beneficial for operations assessments and service planning, external datasets that can supplement this analyses. Some datasets, including those provided by local agencies and crowdsourcing websites, can be used at little to no cost. Other datasets, including cellphone data repositories, can be used at a potentially high price. Much of this data is useful for understanding mobility and travel behavior and can be used in conjunction with agency-collected data.

Case study: StreetLight Data, data software—San Francisco, CA (StreetLight Data)

StreetLight Data has been able to partner with cell-phone providers to offer anonymous position and movement data for millions of trips by using cell phone check-ins and assumptions about travel speed. The San Diego Association of Governments partnered with StreetLight Data to understand the change in travel patterns of individuals using a private toll road after the toll was reduced. StreetLight's metrics were able to illustrate the shift in drivers' behavior, both spatially and temporally. Another company that uses data in a similar way is Airsage (Airsage "Dramatically Better Population Analytics").

Case study: Tiramisu, smartphone application—New York, New York (Weber 2011)

Tiramisu is a smartphone application that allows riders in New York to "check in" when they board a bus. By crowdsourcing this data, Tiramisu provides bus-arrival predictions and track trends on the extent of full buses.

3.1.4 Big data best practice: Analyze maintenance data to inform asset management strategies

In addition to using big data to potentially better inform system planning, there is an opportunity to use a large quantity of data to track maintenance performance and asset management. Sound Transit currently collects large quantities of data from its construction contractors. Sound Transit is currently deploying Maintenance Management Information System (MMIS) programs to track maintenance needs and asset performance over time. This data can be used to develop maintenance strategies, inform state of good repair decisions, and determine provisions for capital replacement.

Integration of transaction and asset management data into some 'dashboard' application could also help decision makers understand overarching trends and identify issues or opportunities which may not be apparent from a single source. For example, managers may observe a maintenance issue at a certain location that is also associated with very high ridership, and as a result, make improvements to similar high-ridership locations to proactively prevent asset deterioration.

3.1.5 Big data—Potential benefits

The use of big data provides transit agencies with a number of potential benefits including understanding how riders use their system, getting real-time updates on how their system is performing, and tracking maintenance and runtime data to address problems before they occur. Combining big data with general mobility data (e.g. CTR data and APC data) can also be used to identify corridors with appropriate transit-supportive characteristics to focus improvements in corridors that can support transit.

These insights could enable transit agencies to make service decisions to improve efficiency, cut costs, and understand gaps in service delivery. The use of big data such as anonymous ORCA information could be highly cost effective as it allows transit agencies to use a basically free dataset.

3.1.6 Big data—Potential challenges

A number of potential challenges are associated with using and providing big data, most notably ownership, format, and privacy. As the process of completing data collection is often contracted out to private vendors, being able to access smartcard data is often a challenge for transit agencies. Additionally, the format of the collected data is often inconsistent with the format needed by the agencies. As a result, agencies may have to spend time and resources to obtain their data and have it processed so that it can be used. Additionally, the tasks of pulling data out of existing software systems, getting it into a user-friendly format, and interacting with data users such as developers also requires collaboration between different departments within agencies that may not have previously worked together.

3.2 Transportation demand management

TDM includes a number of tools and programs that focus on changing travel demand to maximize the use of existing services and infrastructure. TDM aims to make it easier for households, employees, and visitors to make more of their trips on transit, by bike, foot, or by telecommuting. TDM strategies have the potential to improve the utilization of existing transit services and transportation infrastructure, and can result in cost savings to companies and individuals. This topic explores some of the opportunities and best practices associated with TDM, including partnering with private agencies and working with communities using incentive programs.

3.2.1 TDM best practice: CTR in the central Puget Sound region

One of the largest TDM programs in the country is the Commute Trip Reduction (CTR) program, which became law in 1991 as part of the Washington State Clean Air Act. The program generally requires all employers with more than 100 employees at a worksite to develop and implement a CTR plan to reduce drive-alone commute trips. Smaller employers can voluntarily conform to the CTR requirements. In future years, the CTR Board hopes in engage a larger range of employers by targeting employers with less than 100 people, seasonal-agricultural worksites, colleges and trade schools. The requirements of this program have resulted in many employers providing transportation benefits to their employees, and Washington State overall has had less of an increase in the percent share of drive-alone trips compared to the national average. Since 2007 vehicle miles traveled have been reduced by an annual average of 37.7 million *(Washington State Commute Trip Reduction Board, 2014).*

In the Puget Sound region, many employers participate in pass programs offered by transit agencies. King County initially implemented the U-PASS and FlexPass programs to increase public transit use by students and employees at large companies. King County Metro partnered with other transit agencies, including Sound Transit after its formation, to provide transit services to employees covered under the FlexPass program.

Various TDM programs in the central Puget Sound region have proven to be effective. For example, in 2012, Seattle became the fifth city in the U.S. to have more than 50 percent of its residents commute to work by a mode other than driving alone. The extent of CTR efforts in the central Puget Sound region has resulted in a robust ridesharing infrastructure. The programs, policies, transit connections, incentive programs, etc., help provide a substantial basis to build upon when developing future TDM programs that will support Sound Transit's goals.

There is also an opportunity to improve integration between TDM programs and other regional initiatives. PSRC has developed a working group to identify opportunities to connect with economic development, health, energy and sustainability initiatives in the region.

3.2.2 TDM best practice: Partnering with private organizations

The number of privately-operated employee shuttles in major cities such as San Francisco, Chicago, and New York has grown significantly in recent years. In the Puget Sound region, Microsoft, and the University of Washington provide shuttle services for their employees that make connections between various locations in Seattle and Redmond. Seattle Children's Hospital also provides shuttle services for employees and current patients with service to destinations such as the University District, downtown, and the hospital main campus.

Shuttles support important citywide and regional goals by decreasing single-occupancy vehicle (SOV) trips. However, shuttles can provide a challenge to public transit agencies if they use public transit stops by creating vehicle crowding and stop maintenance issues. In addition, the accommodation of private shuttle and rideshare services may not have been recognized during initial HCT station planning and design.

Partnerships between public and private entities provide opportunities to coordinate transportation services, fairly enforce regulations, and establish ongoing communication and problem resolution between shuttle operators, local jurisdictions, and the general public.

Case study: Private shuttle agreement with San Francisco Municipal Transportation Agency—San Francisco, CA (Grzesiakowski 2014)

The City and County of San Francisco is currently running a pilot program that allows private shuttle operators to use city bus stops by obtaining a permit. These private shuttle systems provide private transportation options for employees who have a reverse commute to employment sites in suburban locations. The pilot program charges private-service operators a flat rate of approximately $100,000 per site and a marginal fee of $1/day/bus stop to cover the administrative costs. Private shuttles have become an important component of the regional transportation network in the San Francisco Bay Area (supporting more than 35,000 trips per day).

3.2.3 TDM best practice: Expanded transportation demand management programs

Case study: In Motion, King County Metro—King County, WA

King County Metro has worked with community groups to develop context-specific TDM programs. One theme of these programs is to treat multi-family residences the same as office buildings in terms of

offering demand management incentives. One program that implemented this strategy is *In Motion*. Through this program, residents in North Seattle, Renton, and Burien were incentivized to reduce SOV trips. Individuals who joined the program were eligible for a free ORCA pass and eligible for weekly reward drawings.

Case study: 2010–2015 Work Plan, Downtown on the Go—Tacoma, WA (Downtown: On the Go! 2011)

Downtown on the Go, an advocacy group made up of city of Tacoma officials, private businesses, and non-profit organizations has developed a vision to increase transit use and reduce SOV's in downtown Tacoma. The group builds upon Washington's CTR program by working with employers to encourage employees to live within close proximity to work. The group has also outlined transit goals, including prioritizing improved transit in the downtown area, and improving public awareness of transit services through events such as *Try the Bus*, which could help workers understand their transit options.

3.2.4 TDM—Potential benefits

TDM provides a low-cost opportunity to address a number of Sound Transit's goals including growing ridership, improving efficiency, and cutting costs. TDM strategies indirectly affect these goals by reducing congestion, improving mode-share, enhancing walkability, and mitigating a transit agency's the need to build new roadway infrastructure. This can be done by appropriately pricing different modes of transportation and giving riders better information regarding opportunities to use alternative modes of transportation. TDM strategies can be used on a variety of applications including regional, city-wide, neighborhood or even a single HCT station .

3.2.5 TDM—Potential challenges

One of the primary challenges of TDM is that it requires coordination across a variety of stakeholder groups, including transportation agencies, city agencies, private developers, and the public. Being able to bring these groups together is a major challenge when implementing TDM strategies. However, strong existing programs, policies, connections, and incentives provide a good baseline for future Sound Transit initiatives. Another potential challenge is to incorporate residential areas in TDM efforts, as this is a new area of innovation has not been extensively tried and revised in the way employment-based programs have.

3.3 Parking management at HCT stations

Parking management includes a variety of strategies that encourage more efficient use of existing supply, including park-and-ride facilities at HCT stations. These strategies can improve the overall access to HCT services and potentially change expectations regarding parking requirements. Parking management can help address a wide range of transportation issues, including reducing demand, using existing capacity more efficiently, avoiding overdevelopment of facilities, and improving the user experience.

3.3.1 Parking management best practice: Allow riders to reserve/confirm parking in advance

A number of transit systems, including Sound Transit, have identified ways to deliver real-time parking information. Most of these systems entail a data collection mechanism in the form of spot sensors or crowdsourcing information. Riders are then able to check parking availability either through a phone app or website and may even be able to reserve a spot online. This service improves transparency and allows riders to more efficiently make transportation choices.

Case study: Parking permit sales (Sound Transit)

Sound Transit recently operated a pilot program to test a number of strategies to better manage parking demand at four transit stations: Mukilteo Station, Issaquah Transit Center, Sumner Station, and Tukwila International Boulevard Station. The pilot program included offering permit parking, real-time parking availability data, and better coordination of rideshare programs. With this pilot program, transit riders were able to purchase permits for an administrative fee. Forty percent of the parking supply across the selected stations was reserved for this purpose. Sound Transit staff will study findings of the pilot project and will issue a report to the Sound Transit Board early in 2015.

Through this pilot program, Sound Transit aims to learn about the costs and benefits associated with parking management strategies. Additionally, Sound Transit hopes to identify whether these particular strategies were successful in increasing the overall number of transit riders per parking stall.

Case study: Real-time information on parking availability (Sound Transit)

In another parking management pilot program, Sound Transit customers will be able to use web and mobile applications to check real-time availability of parking spaces at selected park-and-ride facilities. The apps will suggest alternate parking locations if the preferred park-and-ride facility is full. This information is currently available at a number of transit stations. If the pilot program is successful, resources would be needed to implement the program system-wide.

As an additional strategy, Sound Transit is collaborating with other local transit agencies to relocate non-transit-riding rideshares from heavily used park-and-ride facilities to underutilized ones. This pilot program will provide transit riders with assurance of parking during the morning peak period. The program will also furnish Sound Transit with valuable data and customer input regarding the pros and cons of implementing a potential parking permit program.

Case study: Smart parking systems, software

Parking application software allows users so be aware of available parking locations, compare prices, and make reservations in advance. Information is made available to users through smartphone applications, websites, and physical live-feed signage along city roads. These programs have the benefit of reducing traffic by preventing the need for drivers to circle around looking for available parking.

A number of cities are implementing smart parking systems. San Diego is currently running a pilot program that uses smart parking technology at its COASTER commuter rail station park-and-ride facilities (Rodier and Shaheen 2010). When the pilot began, all COASTER stations were experiencing long-term capacity problems. After the pilot, three major recommendations were made to manage parking demand at stations:

- Restrict non-COASTER and overnight parking, or allow at a higher fee
- Encourage carpooling and vanpooling to park-and-ride facilities by offering preferential parking
- Attract frequent riders by offering reserved paid parking

Case study: Parking management, Bay Area Rapid Transit—San Francisco Bay Area, CA (Bay Area Rapid Transit 2014)

Bay Area Rapid Transit (BART) has a number of parking strategies to reduce customer uncertainty and increase efficiency of facilities at its stations. BART facilitates the process by allowing customers to pay for parking using integrated smartcards, cash, or transit tickets. BART also offers a variety of permit options (for a fee); including monthly reserved parking, single-day reserved parking, and long-term/airport permit

parking. Permits can be bought online (Select-A-Spot) in advance to secure a parking stall ahead of time. BART also uses its permitting system to manage who parks at its facilities.

Only individuals who use BART are allowed to buy permits; this is ensured by requiring riders to tap their parking permits once they have entered through the fare turnstiles. Although Sound Transit rail stations do not have turnstiles, payment kiosks for parking could be provided in station areas.

Case study: Metro parking policy, Los Angeles County Metropolitan Transportation Authority—Los Angeles, CA (Los Angeles County Metropolitan Transportation Authority 2009)

The city of Los Angeles has developed a parking policy to assist Metro in managing its existing parking infrastructure. The policy outlines a number of strategies to best utilize its existing resources and mitigate the need for acquiring additional facilities. Some of the identified strategies include the following:

- Improved availability of information(way-finding, available spaces, signage); efficiency of current parking (restriping, count cards, and demand monitoring)
- Formation of parking authorities to facilitate shared parking and universal fee collection
- Implementation of parking fees
- Work with cities to develop better land use

3.3.2 Parking management best practice: Encourage shared parking agreements

Shared facilities represent a potential opportunity to increase supply during peak demand and alleviate demand at park-and-rides and other facilities that are already at capacity. In the Puget Sound region, partnerships with churches, parks, and private garages have provided additional park-and-ride spaces for transit users.

Case study: Shared parking at Portland transit stations, TriMet—Portland, Oregon (TriMet 1999)

The TriMet Park and Ride Policy encourages shared parking near transit stations. Currently, park-and-ride facilities are shared with apartment complexes, a regional justice center, churches, and movie theaters at more than three dozen sites. Metro, the Metropolitan Planning Organization for the Portland region, has developed a handbook on shared parking which includes notes about changes that need to be made to zoning to allow for shared parking uses and changes to parking minimums (Fallen 2013).

Case study: Right size parking, King County Metro—King County, WA (King County Metro and the Center for Neighborhood Technology 2014)

King County was awarded a federal grant to complete a number of pilot studies that aimed to identify the appropriate amount of parking that should be built in conjunction with new development projects. The purpose of the program is to provide data on parking demand in order to support economic development, reduce housing costs, encourage the use of transit, and reduce SOV trips. The project is reaching the end of a pilot phase in which four jurisdictions and three property developments were assisted in identifying the appropriate level of parking for a given community.

Another project that is particularly relevant to Sound Transit is a residential development located next to the Beacon Hill Link Station. At this location, King County Metro has helped identify the appropriate quantity of parking that should be built in order to support the needs of new development and potential spillover parking from the Link station. This project provides an opportunity for the new development to prepare a shared-parking agreement that would benefit stakeholder groups. One proposal for the agreement would allow transit riders to use the residential parking facility during the day for park-and-ride,

given the likely availability of at least some stalls. In the evening, when residents return, these spaces would be available for their use.

3.3.3 Parking management best practice: Parking pricing

There could be benefits resulting from pricing parking to match parking demand with available supply. This approach can help riders can make choices about their transportation mode given their price constraints. By using such pricing strategies, transit agencies can offset the cost of providing park-and-ride stalls while also making other access modes more attractive.

Case study: SFpark, San Francisco Municipal Transportation Agency—San Francisco, CA (San Francisco Municipal Transportation Agency 2014)

SFpark began as a pilot system in 2011and is scheduled to end in 2014. The system dynamically priced parking depending on demand in some of San Francisco's most popular neighborhoods. The goal of the program is to price parking high enough so there would be at least one available spot per block. According to an evaluation completed by the agency, the system was successful in improving parking availability, reducing the amount of time drivers searched for parking, cutting emissions, and raising parking revenue.

3.3.4 Parking management—Potential benefits

Parking management strategies can have a significant effect on the user experience as some systems allow for improved information about parking availability, reliability, and dependability. Additionally, there is an opportunity to price parking and potentially charge premium rates for the added benefit of a reliable parking solution.

Parking management strategies also provide an opportunity to address facilities that are at capacity by developing shared agreements and pricing schemes. Since several Sound Transit park-and-ride facilities are currently at capacity, parking management strategies provide an opportunity to mitigate the growing demand for parking. If parking management strategies include some form of parking charges, alternative access modes to HCT stations can become more attractive.

3.3.5 Parking management—Potential challenges

Parking management is often a difficult task since any restrictions on parking can be challenging to implement. Some individuals could be resistant to give up their parking spaces, developers may be unwilling to design for less spaces, local jurisdictions often have zoning codes with high parking requirements. Thus, consideration of parking benefits should take into account approaches to managing parking inventory that can be mutually beneficial to all groups.

3.4 First mile/last mile

Often the most difficult components of the transportation system to address are the segments from the transit customer's home to transit service and from transit service to the final destination. Many residences and business are not located within convenient walking distances to transit stations. As a result, many transit riders access service by personal vehicle, assuming one is available. At the destination end of the trip, local transit connections and convenient walk access may not be available.

The following items describe some opportunities and best practices associated with first mile/last mile approaches.

3.4.1 First mile/last mile best practice: Improve access for alternative modes of transportation

While driving is often perceived as the easiest way to reach a transit station, providing riders with alternative ways of traveling short distances can be mutually beneficial to a transit agency and a rider.

Case study: FoldNGo—Los Angeles County Metropolitan Transportation Authority and City of Pasadena—Pasadena, CA (Goodyear 2013)

The city of Pasadena currently operates a pilot program in which participants are given $220 toward the purchase of a folding bike under the expectation that they will bike at least two times per week. According to the pilot, data indicate that many riders would be willing to give up driving to a transit station if they had access to a bicycle.

Case study: First Last Mile Strategic Plan, Los Angeles County Metropolitan Transportation Authority—Los Angeles, CA (Los Angeles County Metropolitan Transportation Authority 2013)

Metro has taken a proactive approach to identifying first and last mile solutions by documenting best practices, goals, metrics, and strategies for improving access to transit in Los Angeles County. Metro determined that one of the best ways to decrease SOV use (particularly in the last mile) is to improve safety and access to alternative modes of transportation. Identified strategies include decreasing pedestrian wait times at intersections, improving bike lanes, instituting signal priority for bikes, improving legibility/way-finding, and addressing general safety concerns such as lighting and sidewalk maintenance.

3.4.2 First mile/last best practice: Support the shared modes of transportation

Shared modes of transportation have grown in popularity. There are several variations of rideshare service models. Some of the most common options include:

- Car-sharing—Individuals can rent cars on a localized, per-minute basis from companies, peers, or non-profits.
- Bike-sharing—Individuals can rent bicycles on a localized, per-minute basis from companies, peers, or non-profits.
- Transportation network companies (TNCs)—Private mobile app platforms allow passengers to connect with drivers interested in providing a taxi service.
- Taxi-sharing—Private mobile app platforms allow individuals to hail and share taxis.
- Carpooling—Passengers can coordinate rides with other passengers interested in completing similar trips.

The following sections provide further insights on these shared modes of transportation.

Case study: Carshare-transit collaboration, Cincinnati Metro—Cincinnati, OH (Fallen 2013)

The Southwest Ohio Regional Transit Authority in Cincinnati collaborated with Zipcar to promote car-sharing as a last-mile solution that could be used along with transit. The partnership brought Zipcars to stations and offered discounts to riders. Reportedly this approach encouraged carsharing and reduced the level of car ownership.

Case study: Car-sharing prioritization—San Francisco, CA (Bialick 2014)

A pilot program began in San Francisco in summer 2014 to offer 900 parking spots exclusively to car-sharing companies. This project aims to expand the availability of car sharing across San Francisco, increase the usage of car sharing, and preserve or increase car share options. One of the key challenges for

expanding car sharing is the difficulty of acquiring parking spaces. This pilot program is a potential model of how policy can inform car-sharing opportunities and indirectly affect behavioral transportation choices.

Case study: Citi Bike Bikeshare—New York, NY (Gordon-Koven 2014)

Citi Bike in New York has proven to be one of the most successful bike-sharing programs currently implemented in the US. Much of the success in New York is attributed to the fact that many of Citi Bike's bicycle facilities (72 percent) are located within close proximity to transit stations.

With the new bikesharing program in Seattle (Pronto Cycle Share) there is an opportunity for Sound Transit to work with the vendor to coordinate bicycle docking facilities with Sound Transit HCT stations.

Case study: Car2go—Seattle, WA (Barnett 2014)

In December 2012, the Seattle City Council adopted a pilot program for Car2go to allow Car2go vehicles to pay an annual fee for use of public parking spaces. Car2go varies from other carsharing services by not requiring users to return the vehicle to the starting location, thereby allowing for one-way trips.

3.4.3 First mile/last mile—Potential benefits

Opportunities to encourage riders to use alternative modes of transportation, including bicycles and shared-ride services, represent a potential cost savings and an ability to reach a difficult target audience. Where feasible, incentive programs could be less expensive than building new park-and-ride facilities and also could create opportunities to not only reduce demand for parking but foster long-term shifts in travel behavior.

3.4.4 First mile/last mile—Potential challenges

Regulation can be a major challenge for emerging ridesharing services. While these types of ridesharing services have created a new marketplace with both opportunities and risks, transit systems, local jurisdictions, and shard-ride companies will need to develop policies that support safe, equitable, and affordable services and facilities to accommodate them.

Many shared services, including Uber in New York, have faced obstacles by local jurisdictions and taxi companies. There are questions around insurance, legal liability, and taxation. Transit agencies' ability to proactively develop policies would allow these companies to operate in a way that is mutually beneficial to all parties.

3.5 Customer experience

While often challenging to quantify, the rider experience is one of the most important factors influencing mode choice and ridership. Sound Transit has an internal committee which focuses on issues related to rider experience. Additionally, Sound Transit has developed a number of metrics to measure quantitative aspects of the customer experience including on-time performance standards, crowding levels, number of complaints, directness of travel calculations, and passenger amenity standards.

To better understand the quality of the rider experience, Sound Transit has developed a number of tools to collect qualitative data, including an annual onboard survey and SoundWaves, an online panel of Sound Transit riders. Through these survey mechanisms, riders are asked to rate their transit experience and provide suggestions regarding how to improve service. While Sound Transit has put a number of mechanisms in place to collect rider feedback, the system could be improved by streamlining and simplifying the process to allow riders to easily provide feedback while using agency facilities, such as through a mobile application.

3.5.1 Customer experience best practice: Focus on branding and wayfinding

A number of transit agencies have developed best practices for successfully attracting riders and making transit easily accessible. EMBARQ, a program of the World Resource Institute, issued a report which examined best practices for improving the customer experience. Some of the best practices EMBARQ identified include:

- Build a strong brand which is consistently portrayed by all employees and services
- Systematize information dissemination by maintaining the brand across all user information systems
- Provide system information which is simple and high-quality
- Understand the needs of riders and provide mechanisms for collecting feedback, and
- Tailor messaging to appropriately target your audience, and control an agency's image.

Case Study: Redesigning bus shelters, Municipal Transportation Authority—San Francisco, CA (Roth 2009)

In 2013, San Francisco updated its bus shelters to be artistic, distinct and utilitarian. The new shelters, designed by a local architect, contain solar panels, which power a real-time-arrival display. As such, the structures are aesthetically pleasing, bring attention to the transit system and provide riders with important travel information. These bus shelters also provide an opportunity for transit agencies to collect revenue though selling ad space.

Case Study: Transit branding—Los Angeles, CA (Weber, 2014)

The Los Angeles County Metropolitan Transportation Authority (Metro) has made a large investment in its transit branding. Largely supported by an internal design team, Metro has worked to create a legible, consistent and transparent identity. Maps, advertisements, safety warnings, subway stations, bus shelters, webpages and transit alerts are formatted with a systematized and consistent set of design standards.

Case Study: Displaying transit arrival information—King County, WA (One Bus Away)

One opportunity to merge big data with the customer experience is by displaying real-time arrival data at transit stops and stations. In Seattle and other locations, a real-time passenger information platform called One Bus Away uses global positioning tracking to predict accurate arrival times for transit vehicles. These estimates are made available through the Internet via wireless devices such as smartphones and text messaging as well as electronic signs at transit stops and stations.

By displaying arrival information at transit stations and stops, agencies are able to deliver transit information to a wider range of riders. These include riders at RapidRide stations in King County.

3.5.2 Customer experience best practice: Support E-commerce

The ability to purchase and store transit tickets electronically through the Internet can be both beneficial to transit agencies and transit riders. With electronic tickets, riders can conveniently buy fare cards online or via their phone. Additionally, electronic applications make it convenient for transit agencies to process and collect these fares.

Case study: Mobile ticketing—Portland, Oregon (Schaus 2013)

Tri-Met offers riders the ability to buy transit tickets through a smartphone application. This application is available free-of-charge to transit riders. This improves the user experience as potential riders do not need to seek out locations to buy tickets. Mobile ticketing also provides Tri-Met with a more cost-effective way to sell transit tickets and an opportunity to collect additional data about its riders.

Mobile ticketing removes the costs associated with processing cash fares. It also allows Tri-Met to know when and where riders are when they purchase tickets. GlobeSherpa was responsible for developing the mobile ticketing app for TriMet. In September 2014, GlobeSherpa was in negotiations with the San Francisco Municipal Transit Agency to build a mobile payment platform.

3.5.3 Customer experience best practice - Improve service reliability

By focusing on on-time performance, safety, and headways, transit agencies can ensure that their services are reliable and dependable to the rider. The following items further describe examples of how the customer experience has been addressed through innovative approaches.

Case study: Connected vehicle research (U.S. Department of Transportation 2014)

Recent research initiatives on the Transit Connected Vehicle (CV) Research Program identified opportunities for transit agencies to improve reliability and deliver better service to customers. The CV program, which focuses on enabling communications between various types of vehicles, is similar to the Intelligent Transportation Systems (ITS) Vehicle-Infrastructure Integration (VII) effort by the U.S. Department of Transportation.

These CV communications can be used to relay information, but they incorporate safety-related features such as crash avoidance, lane departure warnings, or other safety advisories, including identification of hazardous roadway conditions. Future CV applications could also result in greater fuel efficiencies while enhancing the transit customer experience. These enhancement for customers could be achieved by improving bus operating efficiencies and providing real-time bus headway information to drivers to reduce the likelihood of bus bunching.

Case study: Combatting bus bunching, via analytics—San Sebastian, Spain (Cosgrove 2013)

A research group from the University of California, Berkeley has developed a tool that alerts bus drivers to speed up or slow down depending on the overall on-time performance of the transit system. This software was tested by San Sebastian's transit agency, *Dbus*. Through the utilization of this technology, Dbus was able to reach an 80 percent on-time performance and cut down variability in wait times. Optimizing on-time performance allows for a better user experience and ensures that the overall system is functioning as efficiently as possible.

3.5.4 Customer experience: Potential benefits

Improving the customer experience makes transit more appealing and accessible to riders. By focusing on the customer experience, transit agencies can ensure that they are providing the best possible service given their financial, build, and policy constraints. Focusing on areas such as safety, aesthetics, information dissemination, reliability, ease of use, and wayfinding could lead to a general improvement in the perception of transit services and travel behavior.

3.5.5 Customer experience: Potential challenges

For the mobile ticketing applications, there could be potential concerns regarding the demographic make-up of potential users. The perception may be that because these new applications require smartphones, their use may be limited to those transit riders with relatively high incomes. However, research (Pew Research Center, 2014) indicates that 47 percent of people with an annual household income under $30,000 have a smart phone, while 53 percent of people with an annual household income between $30,000 and $50,000 have a smartphone, compared with an overall ownership rate of 58 percent. Furthermore, minorities are more likely to have a smartphone (59-61 percent) than non-minorities (53 percent). While smartphone ownership is highest in the younger age groups, 49 percent of people aged

50 to 64 have a smartphone. Thus, while there is a slight decline in smartphone ownership at lower income levels, the gap continues to close and minorities already have higher representation than non-minorities.

Another potential challenge related to user experience is deciding how to allocate funding between qualitative and quantitative service improvements. Qualitative improvements could include addressing safety concerns, building a platform for obtaining rider feedback or investing in branding, while quantitative improvements could include increasing the size of the transit service network or the extent of service operations. Nonetheless, research has shown that addressing customer concerns such as system access, ease of wayfinding, and the perception of safety, are positively correlated with ridership.

4 Potential Approaches for Innovation-Related Strategies

This section of the issue paper presents potential approaches to innovation-related strategies that Sound Transit can consider as part of its Long-Range Plan update and in the next System Plan. These strategies are based in part on key results of the research topics and case studies presented in Section 3 of this paper. In addition to recommended innovation strategies, this section includes a qualitative estimate of benefits for each strategy under the following categories: ridership growth, efficiency gains, improved customer satisfaction, and reduced costs.

4.1 Long-Range Plan

The updated Long-Range Plan could include language for an Innovation Fund, and could describe the desired outcomes of an innovation program while also including a set of best practices for funding and implementation in project development. The Long-Range Plan could also include a description of how innovation funds would be used and distributed to the various chosen innovation approaches.

In the current Long-Range Plan adopted in 2005, the section on *Working Together—a Coordinated System of Services* includes innovation-related language on developing uniform fare media that can be used on Sound Transit and regional partner services, making transfers convenient. This element has been implemented through the ORCA program. Under this section, additional language could address the major strategies that are further described in Section 4.2. Topics in any potential additional language could include:

- Expanded use of anonymous ORCA information for assessing current services and identifying future changes
- Transportation demand management initiatives, including those that go beyond employer-based efforts
- Expanded parking management efforts
- Recognition of emerging ridesharing services to help address first mile/last mile needs
- Approaches to enhancing the transit customer experience

4.2 Potential innovation-related strategies

Table 3 provides an overview of potential innovation-related strategies that could be considered for funding during system plan development. These strategies are based on case studies and other direction as identified in Section 3 of this issue paper. The table also provides a summary of how potential challenges for these strategies can be addressed. The following sections further describe potential strategies.

4.2.1 Big data

One potential innovation approach involves using big data available from the ORCA pass for a variety of purposes. Expanded use of anonymous ORCA card information could allow for comprehensive analysis of ridership patterns. Some applications could be easily achieved, while others would require some level of research.

Table 3. Potential innovation approaches

Innovation topic	Potential approaches	Key benefits				Addressing potential challenges
		Ridership growth	Expanded applications of existing data	Improved customer satisfaction	Cost savings	
Using big data—smartcard and open data	Expand use of information from ORCA card transactions	Expanded information on transit riders could allow Sound Transit to target new markets and increase ridership.	Expanded use of anonymous ORCA card information could allow for a more comprehensive analysis of ridership patterns.		The use of big data information would allow for a comprehensive and ongoing review of customers' travel patterns without incurring major additional costs to Sound Transit.	Although there may be challenges associated with obtaining data from the vendor, and overcoming security and technological issues, other transit agencies have shown these to be surmountable obstacles.
	Make anonymous ORCA data open and easily accessible to the public			Customers could access service information through potential apps based on anonymous ORCA data.	Partnerships could be developed with outside research organizations to achieve research results while minimizing agency costs.	Privacy concerns could be addressed by filtering the database to limit information to only that which is relevant to research.
	Incorporate big data from outside sources, such as cell phone data, CTR data, or Census data.	Expanded information on transit riders could allow Sound Transit to target new markets and increase ridership.	When combined with results from anonymous ORCA card information, a comprehensive database for operations analysis and other purposes would be provided.			Potential costs associated with outside sources could be mitigated through limited but focused use. There can be potential collaborations with organizations outside Sound Transit.
Transportation demand management	Support existing demand management programs—employers	Potential ridership gains could be achieved without major increases in operating and capital costs.				The effort would require coordination across a variety of stakeholder groups, including transportation agencies, city agencies, private developers, and the public. Bringing all of these groups to the table is one of the key challenges when implementing TDM strategies. Taking explicit steps to include public, private, and non-profit groups should be made to ensure the success of TDM initiatives.
	Expand existing demand management programs—residential areas	Potential application of TDM in residential areas near HCT stations could increase ridership.				Take explicit steps to include public, private, and non-profit groups to ensure the success of TDM initiatives and reduce barriers to joining demand management programs.

Table 3. Potential innovation approaches (continued)

Innovation topic	Potential approaches	Key benefits				Addressing potential challenges
		Ridership growth	Expanded applications of existing data	Improved customer satisfaction	Cost savings	
Parking management	Expand existing pilot program	Higher parking turn-over, additional carpool users, and relocating rideshares could attract additional riders.		Participating riders can be assured of using park-and-ride spaces.		Coordination would be required regarding access planning and design for HCT extensions .
	Share parking with nearby developments				Shared parking would eliminate the capital and operating costs associated with added park-and-ride capacity at HCT stations.	Potential issues can be identified on a station-specific basis.
First and last mile	Coordinate with emerging transportation network companies	Higher ridership could be achieved by accommodating new forms of rider drop-offs.			Higher ridership could be achieved without a major increase in capital costs	Coordinate access planning and design for rail extensions—possible facilities for accommodating expanded passenger drop-off volumes from private rideshare services. Recognize potential station-area changes and how park-and-ride access could shift to higher volumes for drop-offs.
Customer experience	Provide mobile ticketing opportunities	Mobile ticketing for casual riders and special events can help achieve higher ridership and more managed passenger accommodation.			Eliminates costs associated with processing cash fares. Ease of use could appeal to more riders.	Although the perception exists that smartphone users are likely more affluent, research indicates that those with lower incomes use their smartphones as frequently as those in other income groups.

For example, using anonymous ORCA data to establish origin–destination patterns is relatively straight-forward for Sounder and Link light rail trips since riders tap their ORCA cards at the beginning and the end of their trips. For buses, however, patrons tap only upon boarding, so research must be conducted to estimate destinations. This could be done by: (1) observing subsequent trips by the same card and estimating the destination, or (2) by analyzing data from other sources. Since bus ORCA readers are not stationary, the analysis must also use automatic vehicle location systems to identify the location of the bus when the card was tapped.

Big data can also be used as a basis for potential research efforts conducted by outside sources. The collaboration between TfL and MIT, described in Section 3, is one example of transit data being available for focused research. Many projects completed at MIT were later used to inform system-wide planning by TfL. Partnering with universities provides an opportunity for a transit operator to analyze large quantities of data without the need for additional agency staff and associated costs.

Privacy could be a concern with the anonymous ORCA card dataset. Trips in the database are recorded with the unique ID of the ORCA card. For people who have registered their ORCA cards online (to protect against loss or theft of the card), there is a linked table where this personally identifiable information can be obtained. While this linked table should never be provided when analyzing travel patterns, other steps can be taken to protect user privacy:

- One possibility is to replace the unique card IDs with random numbers. This randomization may be applied at a weekly or monthly level so that the same card ID has a new random number for each week or month of observed data. While this prevents long-term analysis of individual travel patterns, these long-term individual patterns may be of less interest than system-wide and short-term measures and may be a reasonable trade-off for enhanced privacy. The American Community Survey is an example of how data can be aggregated to the level of block or block group with additional measures built into ensure that data points could not be traced back to an individual.

- Gathering data from existing software systems, translating it into a user-friendly format, and interacting with data users such as developers requires collaboration between different departments within agencies. These departments may not have had occasion to work together previously. One example of an agency addressing these challenges is TriMet in Portland. TriMet employed in-house developers that gave it the capacity to build its own tools, including system-wide algorithms and predictive models. Additionally, the agency's lawyers were well versed in open source licensing options and were able to work with the data-collection vendor regarding an open data strategy for the disclosure of transit information.

- Other transit agencies, including TfL, and the Chicago Transit Authority, have successfully made their transit data to the public, and are examples of how big data can be shared without disclosing personally identifying data. A more in-depth assessment of the format of anonymous ORCA data should be completed to understand if experience on maintaining privacy by other agencies could be applicable and helpful to Sound Transit.

Maintaining user privacy is a key requirement prior to public release of anonymous ORCA transaction data. Additionally, state law imposes privacy protections on personally identifying information. According to Sound Transit, " 'Personally Identifying Information' (PII) means the following information when collected by the Agencies under the ORCA Program: a natural person's name; and, if combined with said name, the address, telephone number, e-mail address, date of birth, Regional Reduced Fare Permit-related

information, photo, and check/debit card/credit card information." Nevertheless, the benefits obtained by releasing sanitized data to the public cannot be understated—there is immense potential for ground-breaking new third-party apps and innovative data analysis.

4.2.2 Transportation demand management

A potential strategy under TDM is to build off of existing CTR programs to include residential areas near HCT stations. This strategy presents an opportunity to increase transit ridership without incurring major capital or operating costs to Sound Transit. The strategy can incorporate results of King County Metro, Community Transit, and other local agencies' efforts with community groups to develop context-specific TDM programs. As described in Section 3, these efforts include opportunities to treat multi-family residential buildings the same as office buildings in terms of offering demand management incentives.

Another potential TDM strategy is to focus on supporting privately operated service, by offering special permitting, which provide shuttle services that make connections between various locations in Seattle and Redmond. These strategies would help address reverse commute employment markets in suburban locations. These markets will take on more importance as Sound Transit extends its light rail lines under ST2 and potentially under future System Plans. The accommodation of private shuttle and rideshare services also can be recognized in HCT station planning and design.

4.2.3 Parking management

Expansion of reserved parking could address future constraints at existing HCT stations and those along future rail extensions. This strategy would recognize current Sound Transit efforts relating to parking management at some stations; however, consideration could also be given to paid parking at some stations. These strategies are further described below.

Integrated fare/parking payment

As described in Section 3, transit systems such as BART in the San Francisco Bay Area have a number of parking strategies to reduce uncertainty and increase efficiency of facilities at their rail stations. The parking payment process is facilitated by allowing users to pay for parking using smartcards, cash, or transit tickets.

Consideration could also be given to a permitting system to manage who parks at their parking facilities. Only individuals who will use the transit system are allowed to buy parking permits. This results in park-and-ride capacity being used by transit customers, thereby eliminating the potential for capacity to be used by carpool and vanpool users. This approach would be particularly relevant to Sound Transit and its Transit Partners given the use by carpools and vanpools at busy park-and-ride facilities. There is also an opportunity for ST to work with other transit agencies to identify alternative parking locations for carpools and vanpools.

Dynamic park-and-ride charges

Another potential strategy involving parking management would draw from the Sound Transit parking pilot programs. Similar to the current effort in San Diego County for COASTER commuter rail service, the strategy can encourage carpooling and vanpooling to park-and-ride facilities by offering preferential parking and attract frequent riders by offering reserved paid parking.

4.2.4 First and last mile

Transit ridership can be increased through accommodating non-traditional rideshare modes such as TNC's. This accommodation can include facilities for accommodating expanded passenger drop-off volumes and recognizing potential station area changes and how park-and-ride access could shift to higher volumes for drop-offs.

The approach to expanded passenger drop-offs could consider the collaboration done by the Southwest Ohio Regional Transit Authority with Zipcar to promote car-sharing as a last-mile solution. The encouragement of higher levels of rider drop-offs at stations can also consider conditions in the overall station area, including sidewalks. The program by Metro in Los Angeles County improving safety and access for alternative modes of transportation can provide direction. But, as Sound Transit considers potential HCT developments in the next System Plan, accommodating alternative access modes could be considered at key stages of project development.

4.2.5 Customer experience

Providing mobile ticketing opportunities via smartphones can enhance transit customers' experience while also increasing ridership. Mobile ticketing could broaden the markets using HCT beyond regular commuter/student use. As is the case with the mobile ticketing program by TriMet and other systems, this strategy would improve the user experience. Potential riders would not need to seek out locations to buy tickets. From Sound Transit's perspective, mobile ticketing for casual riders and those attending special events can help achieve system higher ridership and more managed accommodation of passengers at HCT stations and buses.

The ST2 system plan funded research and technology to make transit more convenient and easier to use by transit customers. In the next System Plan, additional discussion of goals and desired outcomes of the innovation fund could help guide future funding of innovation approaches.

5 Next Steps

Implementing a combination of innovative best practices could allow Sound Transit to focus on maximizing transit ridership by improving service and market efficiency. A dedicated funding source, such as the Innovation Fund, would allow Sound Transit to further research and implement programs to increase ridership outside of new investments in large capital projects.

Developing a dedicated program and funding source in future Sound Transit plans and funding packages would allow the agency to further develop, research and implement innovative best practices.

There are some immediate steps which may be taken at a very low cost to foster innovation, particularly with regard to big data. Chief among these is use of existing data sources already available to Sound Transit, including the anonymous ORCA database. Releasing these and other datasets to the public would immediately spur development activity which can lead to innovative apps similar to the success of apps like One Bus Away, such as mobile payment apps or apps making it easier for visitors to use Sound Transit. Sound Transit could even consider sponsoring a public competition with a modest prize for innovative apps which meet Sound Transit's goals of improving the customer experience.

Sound Transit can also partner with universities and other institutions to sponsor advanced research similar to the examples provided by TfL and their partnership with MIT. The relative cost of utilizing and providing access to these datasets is very low compared to the potential benefit. Expanded use of this data further justifies the resources already applied while developing the anonymous ORCA database thus far.

Sound Transit also has an opportunity to partner with ridesharing service to foster innovation at a low cost. Opportunities to incentivize riders to use alternative modes of transportation, including bicycles and shared-ride services, represent a potential cost savings, ability to reach a difficult target audience, and opportunity to provide first-mile/last-mile solutions. Two ways Sound Transit could support ridesharing services include (1) publicizing real-time operational transit data and (2) promoting a universal access card. Also, by providing operational transit data available to mobile application platforms, individuals can make real-time decisions regarding mode choice. For example, applications such as Ridescout allow individuals to compare the cost, distance, and wait times for different modes of transportation.

Using U.S. Department of Transportation research results on CVs, there could be opportunities for improving operations of ST Express vehicles. These opportunities could result in a range of benefits to Sound Transit, including fuel savings and higher customer satisfaction.

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